Art. V.—*Experiments upon the Hardwoods of Australia.*

A compilation by F. A. Campbell, C.E.

[Contributed 11th May, 1882.]

The strength, durability, and other properties of the colonial hardwoods is a subject involved in considerable obscurity. This arises from the small number, and the fragmentary nature of the experiments yet made, the incompleteness of the records, the great diversity of results where uniformity was to be expected, and the want of exactness in the designation of the various timbers tested.

Notwithstanding that the experiments are few in number, and many of these incomplete, it might, I think, be a work of some interest and service, a work, moreover, which as far as I know, has not yet been attempted, to collect and compare the records of those experiments which have been made up to the present time, to note the conditions under which they were carried out, and to place in a convenient form for reference mean results derived from the whole of the observations.

Such a work would establish an index and starting-point for those who might wish to follow up the subject, and would furnish engineers, architects, and others with at least approximate values for many of the properties of the various timbers tested. To accomplish this in a concise form, and as far as the data which I have been able to collect will permit, has been my aim and desire in writing this paper.

The useful hardwoods of Australia belong almost entirely to the Eucalypt family, and to this fact is due much of the difficulty in affixing the true names to the timbers procured for the purpose of experiment; for not only do many of the varieties greatly resemble one another, and bear in consequence the same popular name, but the same variety is frequently so altered by the influence of locality, that it goes by many different names.

This of course causes much confusion, and detracts greatly from the value of those experiments, where the true botanical names have not been supplied. There is now, however, being issued from the press a work which should do much to rectify this. The *Atlas of the Eucalypts,* by Baron F. von Mueller, supplies a want long felt, and supplies it in a manner eminently worthy of the genius and learning of the author.

I will now proceed to notice the different series of experiments which have been made upon colonial timbers up to the present time, and to which I have had access.

Fowkes.—These were experiments made by Colonel Fowkes upon timbers sent to the International Exhibition of 1862. A great variety of woods from the different colonies came under his notice. The experiments upon them are numerous and very fully recorded. Specific gravity, crushing weights along and across the fibre, elasticity, and transverse strength were tested. The scantlings were 12 inches between bearings and 2 inches square, 1-inch cubes being used for crushing weights.

This is the most extensive series of experiments yet made upon colonial timbers, but its value is considerably diminished, from the fact that the botanical names of the trees furnishing the specimens have not been given.

Sydney Mint, 1858.—These are taken from May's *Australian Builders' Price-book.* They were carried out by the Commissioner of Railways, four experiments being made upon each of four different kinds of woods. The scantlings were 4 feet between the bearings and $1\frac{3}{4}$ inches square. Transverse strength only was tested, and no botanical names are furnished.

Sydney Mint, 1861.—This series was carried out by Colonel Ward, and a very full report furnished to the Parliament of New South Wales. A wide variety of the timbers of New South Wales and Queensland are noticed, information being appended as to the locality, size of tree, and uses to which the timber is put. The botanical name is also given in many instances. The scantlings were 4 feet between bearings and 2 inches square. Specific gravity, elasticity, and transverse strength were tested, and a valuable series of experiments is the result.

Victorian Railway Department, 1865.—These were carried out at Sandhurst, Victoria, and are entirely devoted to red-gum timber. Altogether, nine experiments were

made upon scantlings of unusual size—viz., 14 feet 8 inches between bearings—the breadth and depth ranging from $10\frac{1}{4}$ inches by 7 inches to $11\frac{1}{2}$ inches by $8\frac{1}{2}$ inches. The specific gravity, elasticity, and transverse strength were tested, very full particulars as to the deflection being given. These experiments are of great value, on account of the large size of the pieces tested.

Tredgold.—These are taken from Tredgold's *Carpentry*, edition of 1875. The information is stated to have been furnished by Mr. Josiah Atwool, at one time resident in New South Wales. The information refers to the specific gravity and transverse strength of three timbers only, no particulars being given as to how the experiments were carried out.

Laslett.—Mr. Laslett is the author of a work termed *Timber and Timber Trees*, and, when this was written, was timber inspector to the Admiralty. This work is one of the most valuable treatises devoted to timber yet published. In it the author discusses a very great variety of British and foreign woods, and gives details of numerous experiments which he has carried out. Many of the colonial timbers come under his notice, and he applies to them in most cases their true designation. Four to six experiments were made on each variety, the scantlings being 6 feet between bearings and 2 inches square for transverse, 2 inches square for tensile, and various-sized cubes for crushing tests. The specific gravity, elasticity, tensile, transverse, and crushing strengths were tested. Where comparison can be made, the results arrived at by Mr. Laslett are very generally in accord with those of other experimenters, tensile strengths excepted, for which he gives much lower values. The length of the pieces tested for transverse strength is stated to have been 7 feet, but only 6 feet between bearings. Now, in calculating the values of E. and S., Mr. Laslett has unfortunately taken the length as 7 feet, thereby arriving at incorrect conclusions. This is to be regretted, as the error is embodied in the tables, to which one naturally turns for information of the kind. Observing this discrepancy, I have calculated afresh the values of E. and S. for all cases to which I have found it necessary to refer.

Mueller.—These experiments are taken from the *Eucalyptographia.* They were carried out by Baron von Mueller and Mr. Luehmann. The scantlings were 2 feet long and 2 inches square. The specific gravity, elasticity, and transverse strength were tested for twelve different species.

Of course, the various timbers are properly designated; and it is to be hoped that these gentlemen will be able to extend their labours in this direction, as their work derives so much value from the perfect identification of the timbers in hand.

Mitchell.—These experiments were made upon blue-gum timber only; the records being taken from Mueller's *Eucalyptographia.* The scantlings were 7 feet long and 2 inches square. The specific gravity, elasticity, transverse and tensile strength were tested, and the period of seasoning which each piece had undergone is noted.

Campbell.—These were tensile tests only, made by the writer upon nine of the colonial woods, a report of which was read to this Society in May, 1879. The sectional area was from one-sixteenth to one-eighth of an inch. The results obtained are much higher than those of Mr. Laslett, but correspond closely enough with those of Mr. Mitchell, and the quotations in Rankin and Molesworth.

Hurst, Rankin, and Molesworth also give values for different properties of some of the woods, but as these have in all probability been derived from some of the experiments already noticed, I have not made use of them.

In recent numbers of the *Australian Engineering and Building News*, to which I have contributed some papers on the subject, will be found details of the experiments which have here been mentioned. I will in this paper only give in a condensed tabular form, the mean results of the whole, noting opposite to each the names of the experimenters, and by means of the figures under each name, indicating the particular work done by them. The table is arranged in order of the transverse strength of the timbers mentioned.

Species of Timber.	1 Specific gravity.	2 Crushing weight per square inch.		3 E. from forml. $E=\frac{l^3 w}{16\,a d^3\,\delta}$	4 Modulus of Rupture.	5 Tensile strength per sq. inch.	Authority.
		Longl.	Transverse.				
1. IRONBARK— (*E. Leucoxylon and E. Siderophyloia*)	1·117	10,166	4,100	488,066	18,258	15,950	S Mint. 1-3-4. Fowkes. 1-2-3-4. Laslett. 1-2-3-4-5. Tredgold. 1-4. Campbell. 5.
2. TUART— (*Eucalyptus Gomphocephala*)	1·169	9,340	..	447,700	13,890	10,284	Laslett. 1-2-3-4-5.
3. BLACKBUTT— (*E. Pilularis*)	·990	8,449	8,064	313,600	13,529	..	S. Mint. 1-3-4. Fowkes. 1-2-3-4.
4. BLUEGUM— (*E. Globulus*)	1·017	7,730	6,600	509,750	13,140	20,100	Mitchell. 1-3-4-5. Mueller. 1-3-4. Fowkes. 1-2-3-4. Laslett. 1-2-3-4-5. Tredgold. 1-4 Campbell. 5.
5. YELLOW BOX— (*E. Melliodora*)	1·017	..	..	472,605	12,312	..	S. Mint. 1-3-4. Mueller. 1-3-4.
6. BLOODWOOD— (*E. Corymbosa*)	·918	..	..	399,450	11,970	..	S. Mint. 1-3-4.
7. SPOTTED GUM— (*E. Goniocalyx*)	·981	9,072	7,308	322,900	11,943	..	S. Mint. 1-3-4. Mueller. 1-3-4. Fowkes. 1-2-3-4.
8. STRINGYBARK— (*E. Macrorrhyncha*) ..	·995	7,744	6,650	231,850	11,656	22,000	S. Mint. 1-3-4. Mueller. 1-3-4 Fowkes. 1-2-3-4. Campbell. 5.
9. KARI— (*E. Diversicolor*)	·980	12,513	..	568,620	11,640	7,070	Laslett. 1-2-3-4-5.
10. WOOLYBUTT— (*E. Longifolia*)	1·054	7,297	2,968	285,995	11,524	..	S. Mint. 1-3-4. Fowkes. 1-2-3-4.
11. REDGUM— (*E. Rostrata*)	·990	..	..	433,000	10,250	16,400	Vict. Ry. Depart. 1-3-4. Mueller. 1-3-4. Campbell. 5.
12. JARRAH— (*E. Marginata*)	1·007	7,166	..	177,690	9,250	2,940	Laslett. 1-2-3-4-5.

I have also compiled a table in which is given what might be termed safe practical moduli of rupture for six of the principal hardwoods of the group. This I have made up from the different series of experiments, giving them values in accordance with their comprehensiveness and completeness, and then making certain deductions to ensure being upon the safe side. I have confidence that the results present fair average values for the transverse strength of the timbers named; that they err, if at all, in being below the mark; and that they are sufficiently sure data for all calculations for purposes of construction.

Timber.	Moduli of Rupture.
1. Ironbark	16,000 lbs.
2. Bluegum	11,000
3. Yellow box	10,000
4. Spotted gum	10,000
5. Stringy-bark	9,000
6. Redgum	8,000

Tamworth, N.S.W., October 31st, 1881.

Art. VI.—*Floods on the River Barwon.*

By W. C. Kernot, M.A., C.E.

[Read 8th June, 1882.]

Having been prevented by circumstances of a very painful and urgent nature from taking part in the discussion upon Mr. W. W. Culcheth's paper upon the above subject, I venture at this comparatively late period to submit my views upon a question which all will admit to possess the highest practical importance.

The due proportioning of the waterway of bridges is a question of vital moment to the railway, road, or hydraulic engineer. If the waterways are made needlessly large, the waste of money may be most serious; if they are unduly